REMARKS

This is intended as a full and complete response to the Office Action dated May 12, 2003, having a shortened statutory period for response set to expire on August 12, 2003. Claims 1-31 are pending in this application. Claims 1-31 were considered and stand rejected.

Claim 21 is objected to for being a duplicate of claim 20. Applicants have amended claim 21 to claim a different aspect of the invention than claim 20. Applicants submit that the changes made herein do not introduce new matter. Applicants respectfully request withdrawal of the rejection of claim 21.

The Examiner requested clarification of the phrase "the at least partially exposed layer" in claim 7. Applicants have amended claim 7 to replace "the at least partially exposed layer" with "the substrate." Applicants submit that the changes made herein do not introduce new matter.

Applicants have canceled claim 6 and have amended claims 2-5, 13, 14, 17-20, 22-24, and 27 as to matters of form and to clarify the claimed subject matter. Applicants have added new claim 32. Applicants submit that the changes made herein do not introduce new matter. Applicants submit that new claim 32 is patentable for the reasons discussed below with respect to claim 10.

Claims 1-3, 5-6, 10-12, and 16 are rejected under 35 § 102(e) as being anticipated by *Chou, et al.* (U.S. Patent 6,337,277). Applicants have amended claim 1 as to matters of form and to recite a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas and a reactive gas selected from the group consisting of fluorine containing gases and hydrogen. Applicants submit that the changes made herein do not introduce new matter and are supported by the specification.

Applicants submit that *Chou, et al.* does not teach or suggest a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas and a reactive gas selected from the group consisting of fluorine containing gases and hydrogen, as recited in amended claim 1. *Chou, et al.* describes a process of simultaneously etching and passivating an organic polymer layer. The organic polymer

layer is etched with O_2 plasma, and the etched sidewalls of the organic polymer layer are protected by a passivation layer of H_2O that forms on the cooled substrate (column 5, lines 15-25). *Chou, et al.* states that gases such as argon, helium, and nitrogen may be used to stabilize the oxygen plasma used to etch the organic polymer layer (column 9, lines 41-43). After the etch is terminated in the process of *Chou, et al.*, the process gases are terminated, and the temperature of the substrate is raised to melt the condensed layer of H_2O on the organic polymer layer. *Chou, et al.* asserts that no additional process steps are needed to remove residue from the sidewalls, as there is no residue to remove (column 10, lines 44-51). Thus *Chou, et al.* only describes etching a substrate with a plasma of oxygen, and optionally, nitrogen, argon, and helium, and then removing a H_2O passivation layer by heating the substrate in the absence of process gases. There is no teaching or suggestion in *Chou, et al.* of a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas and a reactive gas selected from the group consisting of fluorine containing gases and hydrogen. Thus, *Chou, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising disposing the substrate on a substrate support member in a process chamber, cooling the substrate to a temperature of 100 degrees Celsius or less, and exposing the substrate to a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas and a reactive gas selected from the group consisting of fluorine containing gases and hydrogen, as recited in claim 1. Applicants respectfully request withdrawal of the rejection of claim 1 and of claims 2, 3, and 5, which depend thereon.

Applicants have amended claim 10 to recite a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas. Applicants submit that the changes made herein do not introduce new matter and are supported by the specification.

Regarding claims 10-11, the Examiner states that *Chou, et al.* discloses that the plasma is formed from a gas comprising argon. As discussed above, *Chou, et al.* describes etching a substrate with a plasma of oxygen, and optionally, nitrogen, argon, and helium, and then removing a H_2O passivation layer by heating the substrate in the absence of process gases. *Chou, et al.* does not describe exposing the substrate a pre-

clean process comprising a plasma formed from a gas mixture consisting of a non-reactive gas. Thus, *Chou, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising disposing the substrate on a substrate support member in a process chamber, electrostatically chucking the substrate to the substrate support member, cooling the substrate to less than about 100 degrees Celsius, and exposing the substrate a pre-clean process comprising a plasma formed from a gas mixture consisting of a non-reactive gas, as recited in claim 10. Applicants respectfully request withdrawal of the rejection of claim 10, and of claim 11, which depends thereon.

Regarding claims 12 and 16, the Examiner states that the limitations of claim 12 are discussed in the office action. Applicants submit that the Examiner has not shown how *Chou, et al.* describes transferring a substrate cooled to less than about 100 degrees Celsium to a substrate support member disposed in a process chamber. While *Chou, et al.* describes a process sequence in which a substrate is introduced into a process chamber, disposed on a pedestal, and cooled to a temperature of less than or equal to -10°C on the pedestal, *Chou, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising cooling the substrate to less than about 100 degrees Celsius, transferring the cooled substrate to a substrate support member disposed in a process chamber, and exposing the substrate to a pre-clean process, as recited in claim 12. Applicants respectfully request withdrawal of the rejection of claim 12 and of claim 16, which depends thereon.

Claim 4 is rejected under 35 U.S.C. § 103(a) as being unpatentable over *Chou, et al.* in view of *Maxwell, et al.* (U.S. Patent 5,996,353). Applicants submit that claim 4 is patentable over *Chou, et al.* in view of *Maxwell, et al.* for the reasons discussed above with respect to claim 1, upon which claim 4 depends. Applicants respectfully request withdrawal of the rejection of claim 4.

Claims 7-9, 13-15, and 17-31 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Chou, et al.* in view of *Subrahmanyan, et al.* (U.S. Patent 6,107,192). The Examiner states that *Chou, et al.* fails to disclose etching native copper oxide from an exposed layer, and that *Subrahmanyan, et al.* discloses etching native copper oxide from an exposed layer. The Examiner asserts that it would have been obvious to

modify *Chou, et al.* in view of *Subrahmanyan, et al.* by etching the native copper oxide from the exposed layer because it will remove contaminants prior to metallization. Applicants respectfully traverse the rejection.

Subrahmanyan, et al. describes cleaning features of a substrate with a plasma generated by a remote plasma source and comprising a reactive gas such as oxygen, a mixture of CF_4/O_2, or a mixture of He/NF_3. *Subrahmanyan, et al.* does not disclose the temperature of the substrate during the above plasma cleaning step or suggest that the temperature of the plasma cleaning step is important. *Subrahmanyan, et al.* does state that the temperature of the chamber during a subsequent hydrogen plasma cleaning step may be 350°C to achieve thermal reduction of native oxides. Applicants submit that the subject matter of claim 7 is not suggested by the combination of *Subrahmanyan, et al.*, which includes a plasma of a reactive gas generated by a remote plasma source to clean a previously formed aperture, with *Chou, et al.*, which includes using a plasma of oxygen to form an aperture, cooling a substrate to form a condensed H_2O layer on the sidewalls of the aperture as it is being formed, and melting the condensed H_20 layer to clean the sidewalls. There is no indication in *Chou, et al.* that the process described therein can be used to remove native copper oxide from the substrate. *Chou, et al.* only describes etching and cleaning the sidewalls of an organic polymer layer. *Subrahmanyan, et al.* only describes the use of oxygen or fluorine containing gases, which will not condense and evaporate without contaminating the substrate. The combined references do not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising disposing the substrate on a substrate support member in a process chamber, cooling the substrate to a temperature of 100 degrees Celsius or less, and exposing the substrate to a pre-clean process comprising forming a plasma from a gas mixture consisting of a non-reactive gas and a reactive gas selected from the group consisting of fluorine containing gases and hydrogen, wherein the pre-clean process further comprises etching native copper oxide from the substrate, as recited in claim 7. Applicants respectfully request withdrawal of the rejection of claim 7, and of claims 8 and 9, which depend thereon.

Regarding claim 13, the Examiner states that it would have been obvious to modify *Chou, et al.* in view of *Subrahmanyan, et al.* by cooling the substrate in the

degas chamber because it will help remove gas contaminants. Applicants submit that claim 13 is patentable over *Chou, et al.* for the reasons discussed above with respect to claim 12. Applicants further submit that while *Subrahmanyan, et al.* describes transferring a substrate to a degas chamber before transferring the substrate to a pre-clean chamber, *Subrahmanyan, et al.* does not describe or suggest cooling the substrate to less than 100 degrees Celsius in the degas chamber, as recited in claim 13. Applicants respectfully request withdrawal of the rejection of claim 13.

Regarding claim 14, the Examiner states that it would have been obvious to modify *Chou, et al.* in view of *Subrahmanyan, et al.* by cooling the substrate in the cool down chamber because it allows the substrate to be processed or cooled any number of times. Applicants submit that claim 14 is patentable over *Chou, et al.* for the reasons discussed above with respect to claim 12. Applicants further submit that while *Subrahmanyan, et al.* describes transferring a substrate to a cool down chamber after pre-cleaning the substrate, *Subrahmanyan, et al.* does not describe or suggest cooling the substrate to less than 100 degrees Celsius in a cool down chamber, and then transferring the cooled substrate to a substrate support member disposed in a process chamber, as recited in claim 14. Applicants respectfully request withdrawal of the rejection of claim 14.

Regarding claims 15 and 17, the Examiner states that it would have been obvious to modify *Chou, et al.* in view of *Subrahmanyan, et al.* by etching native oxides, as described in claim 15, or reducing native oxides, as described in claim 17. As discussed above with respect to claim 13, Applicants submit that there is no evidence that the claimed subject matter is suggested by the dissimilar processes of *Chou, et al.* and *Subrahmanyan, et al.* In particular, there is no evidence that a combined process of *Chou, et al.* and *Subrahmanyan, et al.* could etch or reduce native oxides. Applicants respectfully request withdrawal of the rejection of claims 15 and 17.

Regarding claim 18, Applicants submit that *Chou, et al.* in view of *Subrahmanyan, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising disposing the substrate on a substrate support member in a process chamber, exposing an at least partially exposed copper layer on the substrate to a pre-clean process while maintaining a substrate temperature

of less than about 100 degrees Celsius, and depositing a bulk layer of copper on the at least partially exposed layer, as recited in claim 18. Applicants agree with the Examiner that *Chou, et al.* fails to disclose the step of exposing a partially exposed copper layer to a pre-clean process at a temperature of less than about 100 degrees Celsius, and depositing a bulk layer of copper. However, Applicants submit that there is no motivation in *Chou, et al.* or *Subrahmanyan, et al.* to expose an at least partially exposed copper layer to a pre-clean process while maintaining a substrate temperature of less than about 100 degrees Celsius. *Chou, et al.* provides a process for cleaning an organic polymer layer, and *Subrahmanyan, et al.* provides a substantially different process for cleaning a partially exposed copper layer. Applicants respectfully request withdrawal of the rejection of claim 18.

Regarding claims 19 and 20-21, Applicants submit that *Chou, et al.* in view of *Subrahmanyan, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising disposing the substrate on a substrate support member in a process chamber, cooling the substrate at least to a temperature of 100 degrees Celsius, exposing an at least partially exposed copper layer to a pre-clean process, and depositing a barrier layer on the at least partially exposed layer, as recited in claim 19. As discussed above with respect to claim 18, there is no motivation or suggestion in *Chou, et al.* and *Subrahmanyan, et al.* to use the process of *Chou, et al.* on an exposed copper layer, as described in *Subrahmanyan, et al.* Applicants respectfully request withdrawal of the rejection of claim 19, and of claims 20-21 which depend thereon.

Regarding claim 21, Applicants further submit that *Chou, et al.* in view of *Subrahmanyan, et al.* does not teach or suggest a pre-cleaning process comprising exposing the at least partially exposed copper layer to a plasma of a reactive gas selected from the group consisting of fluorine containing gases and hydrogen, as recited in amended claim 21. Applicants respectfully request withdrawal of the rejection of claim 21.

Regarding claims 22-26, Applicants submit that *Chou, et al.* in view of *Subrahmanyan, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate, the method comprising cooling the substrate to a temperature

of 100 degrees Celsius or less in a first chamber, transferring the substrate to a second chamber, and pre-cleaning an at least partially exposed layer in the second chamber while maintaining a substrate temperature of 100 degrees Celsius, as recited in claim 22. While *Chou, et al.* describes a process sequence in which a substrate is introduced into a process chamber, disposed on a pedestal, and cooled to a temperature of less than or equal to -10°C on the pedestal, *Chou, et al.* does not describe a process comprising cooling the substrate at least to a temperature of 100 degrees Celsius in a first chamber, transferring the substrate to a second chamber, and pre-cleaning an at least partially exposed layer in the second chamber. Applicants respectfully request withdrawal of the rejection of claim 22, and of claims 23-26, which depend thereon.

Applicants submit that claim 27 is patentable for the reasons discussed above with respect to claims 18 and 19. *Chou, et al.* in view of *Subrahmanyan, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate having vias containing at least partially exposed copper features, the method comprising disposing the substrate on a substrate support member within a process chamber maintained at a chamber pressure of between about .5 to about 100 mtorr, cooling the substrate to a temperature of between about –40 to about 100 degrees Celsius by maintaining a gas between a surface of the substrate support and a facing surface of the substrate to transfer heat from the substrate to the support member, and exposing the at least partially exposed copper features to a pre-clean process comprising a plasma formed from a gas comprising a non-reactive gas, as recited in claim 27. Applicants respectfully request withdrawal of the rejection of claim 27.

Claims 19, 27-28, and 30-31 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Chou, et al.* and *Denning, et al.* (U.S. Patent 6,451,181) in view of each other. The Examiner states that it would have been obvious to modify *Denning, et al.* in view of *Chou, et al.* by cooling the substrate to a temperature below 100°C because this would protect the sidewall during cleaning. Applicants respectfully traverse the rejection.

Denning, et al. describes a pre-cleaning process that includes exposing a substrate to an ionized inert gas and etching the corners of the features in the substrate. *Denning, et al.* does not disclose the temperature of the pre-cleaning process or

indicate that the temperature of the pre-cleaning process is important. *Denning, et al.* does not suggest or motivate that cooling the substrate below 100°C during cleaning would protect the sidewalls of the substrate during cleaning, as asserted by the Examiner. *Denning, et al.* uses inert gases that would not condense to form a passivation layer on a substrate, as described in *Chou, et al.* Applicants submit that the combination of *Chou, et al.* and *Denning, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate having an at least partially exposed copper layer, the method comprising disposing the substrate on a substrate support member in a process chamber, cooling the substrate at least to a temperature of 100 degrees Celsius, exposing the at least partially exposed copper layer to a pre-clean process, and depositing a barrier layer on the at least partially exposed layer, as recited in claim 19. Applicants respectfully request withdrawal of the rejection of claim 19.

Regarding claims 27-28 and 30-31, the Examiner states that it would have been obvious to modify *Chou, et al.* in view of *Denning, et al.* by exposing partially exposed copper to a pre-cleaning gas because it will help remove contaminants while minimizing copper removal from the surface. *Chou, et al.* provides a process for etching and pre-cleaning an organic polymer layer of a cooled substrate that includes protecting and cleaning the sidewalls of the organic polymer layer. The etching process is substantially stopped when the organic polymer layer has been etched down to previously formed layers 102 (column 12, lines 34-36). Applicants submit that there is no motivation or suggestion in *Chou, et al.* or *Denning, et al.* that applying the process of *Chou, et al.* to an exposed copper surface will help remove contaminants while minimizing copper removal from the surface, as asserted by the Examiner. *Chou, et al.* in view of *Denning, et al.* does not teach, show, or suggest a method for pre-cleaning apertures on a substrate having vias containing at least partially exposed copper features, the method comprising exposing the substrate on a substrate support member within a process chamber maintained at a chamber pressure of between about .5 to about 100 mtorr, cooling the substrate to a temperature of between about –40 to about 100 degrees Celsius by maintaining a gas between a surface of the substrate support and a facing surface of the substrate to transfer heat from the substrate to the support member, and exposing the at least partially exposed copper features to a pre-clean process

comprising a plasma formed from a gas comprising a non-reactive gas, as recited in claim 27. Applicants respectfully request withdrawal of the rejection of claim 27, and of claims 28, 30, and 31, which depend thereon.

In conclusion, the references cited by the Examiner, neither alone nor in combination, teach, show, or suggest the method or apparatus of the present invention. Having addressed all issues set out in the office action, Applicants respectfully submit that the claims are in condition for allowance and respectfully request that the claims be allowed.

The prior art made of record is noted. However, it is believed that the secondary references are no more pertinent to the Applicants' disclosure than the primary references cited in the office action. Therefore, it is believed that a detailed discussion of the secondary references is not deemed necessary for a full and complete response to this office action. Accordingly, allowance of the claims is respectfully requested.

Respectfully submitted,

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